

Segmental Duodenal Resection: Indications, Surgical Techniques and Postoperative Outcomes

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Abstract

Introduction Segmental duodenal resections (DR) have been increasingly performed for the treatment of primary duodenal tumours. The aim of the study is to review the indications for, clinical and operative details, and outcomes of patients undergoing elective DR.

Material and Methods We retrospectively reviewed all patients who underwent elective segmental DR for the treatment of primary duodenal tumours, at a single institution between January 2007 and December 2013. Demographic data, clinical presentation, preoperative investigations, operative details, postoperative complications/mortality and histopathological results were recorded.

Results In the study period, 11 duodenal resections were performed (7 male, median age 61 years). Thirty-six percent of the patients presented with anaemia. Surgical resection included two or more segments in seven patients. The most frequently resected part of the duodenum was segment 3 ($n=7$). Median operative time was 191 min and blood loss was 675 ml. End-to-end and end-to-side anastomoses were performed in equal numbers. The pathology of resected specimens included adenocarcinoma ($n=4$), gastrointestinal stromal tumour (GIST) ($n=1$), adenoma ($n=5$) and lymphoma ($n=1$). Median hospital stay was 14 days. Overall, 30-day morbidity rate was 82 % (78 % Clavien 2 or less).

Conclusions Segmental duodenal resection is a safe and effective surgical technique for the resection of primary duodenal tumours.

Keywords Duodenal resection · Duodenal tumour · Duodenal adenocarcinoma · Duodenal GIST · Duodenal adenoma

Introduction

Duodenal resection (DR) is infrequently performed due to the limited indications for, and technical challenge presented by, segmental resection of the duodenum. Historically, this procedure was most commonly performed for complications of peptic ulcer disease or trauma involving a limited segment of

the duodenum.^{1–3} Over the last decade, the practice of limited duodenal resection has emerged as an alternative to the more invasive surgical approach for duodenal tumours, a pancreaticoduodenectomy (PD).^{4, 5} At present, the commonest indication for elective DR is resection of duodenal adenomas, gastrointestinal stromal tumours (GISTs) and early duodenal carcinomas.

Both villous and tubular adenomas of the duodenum should be resected; when endoscopic resection is not feasible or has failed, surgical resection is indicated.⁶ GISTs, defined as spindle cell tumours which are CD117 (c-kit protein)-positive, account for only 1–3 % of all gastrointestinal tumours, and among them, duodenal involvement is observed in only 3–5 % of cases.^{7, 8} Due to the low propensity of GISTs to invade locally and metastasize, when they arise in the duodenum, they are ideally treated with limited DR. Several recent series have demonstrated that limited DR for duodenal GISTs is feasible, safe, and is associated with equivalent postoperative survival as PD.^{4, 7–13}

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Performing limited DR for duodenal adenocarcinoma is more controversial. The standard surgical approach to invasive duodenal adenocarcinomas is pancreaticoduodenectomy. However, there is data demonstrating comparable oncological outcomes (disease-free and overall survival) for limited DR and PD in the management of duodenal cancers.^{5, 14–16} Although this evidence is based primarily on retrospective studies performed on limited numbers of patients, it suggests the feasibility and safety of performing oncologic duodenal resection, particularly for D3/D4 tumours without local invasion.^{15–20} Given the paucity of such cases, it seems unlikely that a prospective randomized clinical trial will ever be feasible to better compare DR and PD. In the absence of such data, retrospective studies remain the main source of evidence upon which to base decisions about performing segmental duodenal resection for invasive cancers.

The feasibility of performing limited DR depends largely on the duodenal segment involved by the pathology and its relationship with adjacent structures such as the pancreas and common bile duct (CBD). Resection of D1 and D3–D4 is relatively straightforward, while the anatomic relations of D2 with the pancreatic head and the intrapancreatic portion of the CBD make limited resection of this duodenal segment more challenging. The latter is particularly true when the indication for resection is invasive malignancy. For lesions involving D2 where limited DR is being considered and/or attempted, the identification and preservation of the ampulla are a critical component of the procedure.

The aim of this study was to review the indications for, clinical and operative details, and outcomes of patients undergoing elective limited/segmental DR at a tertiary referral hepatobiliary centre.

Materials and Methods

We performed a retrospective review of all patients who underwent elective limited DR between January 2007 and December 2013 at St Vincent's University Hospital. Demographic data, clinical history, operative and histopathological details were recorded. Postoperative complications and mortality were classified using the Dindo-Clavien classification²¹. Patients who underwent endoscopic resections, wedge duodenal resection, pancreaticoduodenectomy, transduodenal ampullectomy, emergency surgical procedures or procedures performed for indications other than duodenal tumours were excluded. Data analyses were performed with Statistical Package for the Social Sciences (SPSS) version 16.0. Descriptive statistics were computed for all variables. The Kolmogorov-Smirnov test was used to determine the variables' distribution. Student's *t* test was used to make pairwise comparisons of

normal distributed parameters. For nonparametric data, continuous variables are presented as median values (and range), and the Mann-Whitney *U* test was used for any two sample comparisons. Dichotomous variables were compared using the Chi square test. All tests were two-tailed, and results with a *p* value of <0.05 were considered statistically significant.

Results

Patient Characteristics

Over the 6-year study period (2007–2013), 11 limited DR procedures were performed at our institution. The majority was male ($n=7$, 64 %), with a median age of 61 years (range 52–81 years). The most common clinical presentation was with a microchromic microcytic anaemia, which occurred in 36 % ($n=4$) of patients. Most patients (73 %, $n=8$) were classified as ASA 2 (mild systemic disease per the American Society of Anesthesiologists Physical Status classification system).

Perioperative and Operative Details

The investigations which diagnosed, characterized and staged duodenal tumours are summarized in Table 1.

Of four patients whose postoperative pathology confirmed a duodenal adenocarcinoma, only one had a concordant preoperative histopathological diagnosis of malignancy confirmed on biopsies. This patient was an 81-year-old female who presented with anaemia and symptoms of gastric outlet obstruction. Although D2 involvement by the tumour was suspected preoperatively in this case, a decision was made to proceed with a segmental DR, due to her age and comorbid state. The other three patients whose final pathology confirmed adenocarcinoma were preoperatively thought to have an adenoma based on endoscopic biopsies taken during their work-up. Imaging did not identify involvement of D2, and so these three patients were considered suitable for segmental duodenal resection. In addition to the aforementioned case, where D2 resection was undertaken for a near-obstructing adenocarcinoma, two other patients were suspected to have D2 involvement based on preoperative endoscopic assessment. In both cases, preoperative endoscopy was performed and excluded ampullary invasion by the D2 lesion.

No patient in this series underwent endoscopic retrograde cholangiopancreatography (ERCP) or magnetic resonance cholangiopancreatography (MRCP) as part of their preoperative assessment.

Preoperative endoscopic ultrasound (EUS) was performed in four (36 %) patients to determine the relationship of the

Table 1 Preoperative detail

		N=11 (%)
Male/female		7/4 (64/36)
Age, years (range) ^a		61 (52–81)
Symptoms		
	Anaemia	4 (36)
	Weight loss	2 (18)
	Pain	2 (18)
	GI obstruction	2 (18)
	Deranged liver function tests	1 (9)
ASA		
	I	1 (9)
	II	8 (73)
	III	2 (18)
	IV	0 (0)
	V	0 (0)
Preoperative investigations		
	Upper endoscopy	11 (100)
	CT	7 (64)
	EUS	4 (36)
Duodenal segment involved		
	D1	2 (18)
	D2	4 (36)
	D3	7 (64)
	D4	4 (36)
Biopsy result		
	Adenoma	7 (64)
	Carcinoma	1 (9)
	Stromal tumour	1 (9)
	Others	2 (18)

^aData expressed as median and range

ASA American Society of Anaesthesiology, CT computed tomography, EUS endoscopic ultrasound, GI gastrointestinal

lesion to the intrapancreatic common bile duct and pancreatic parenchyma. However, EUS was not routinely used as a preoperative test if no CBD or pancreatic involvement was suspected.

Surgical resection included only one duodenal segment in four patients (36 %) and two or more segments in seven patients (64 %). The most frequently resected part of the duodenum was segment 3 ($n=7$). The majority of patients had a primary duodeno-duodenal or duodeno-jejunal anastomoses, while two patients had a Roux-en-Y reconstruction, both of them for tumours involving D1 or D2. Resection of D1 alone was performed in two patients. Reconstruction after D1 resection was performed with a Roux-en-Y loop in one case and by primary end-to-end anastomoses in the second case. A portion of D2 was resected along with D1 in a further four

cases, three of whom had a primary end-to-end anastomoses and one of whom had a Roux-en-Y reconstruction.

No patient underwent preoperative endoscopic cannulation of the ampulla or intraoperative biliary cannulation through the cystic duct in order to find the duodenal ampulla. The ampulla was always identified, in the cases of D2 resection, by palpation and direct visualization after the initial duodenotomy. All anastomoses were hand-sewn with absorbable monofilament sutures. End-to-end and end-to-side anastomoses were performed in similar numbers (Fig. 1).

All patients had one or two surgical drains (passive drains) placed intraoperatively. Median operative time was 191 min (range 120–240 min) and median blood loss was 675 ml (range 50–1500 ml). There were no intraoperative complications or deaths in this series (intraoperative details are summarized in Table 2).

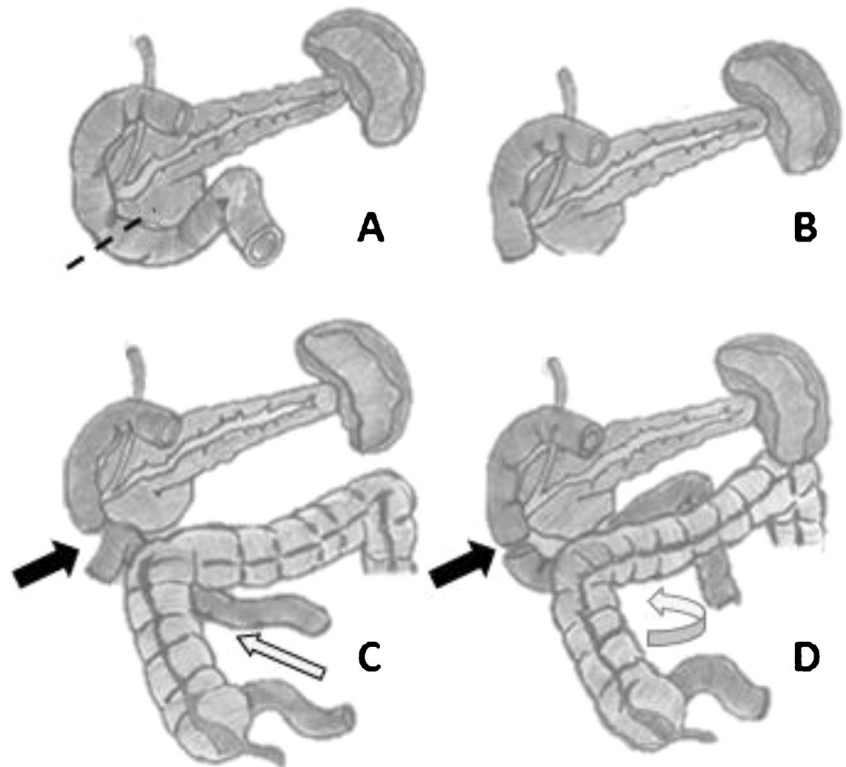
Postoperative Outcomes

Histopathological analyses of resected duodenal specimens identified invasive duodenal adenocarcinoma in four (36 %) patients. Of these four tumours, two had lymphatic involvement (one N1 with 2 of 4 nodes positive, and one N2 with 4 of 14 nodes positive). The tumour stage of these four adenocarcinomas was T1 ($n=1$), T3 ($n=2$) and T4 ($n=1$) per the American Joint Committee on Cancer (AJCC) Tumour Node Metastases (TNM) classification system for small intestinal cancers. The mean number of lymph nodes harvested for adenocarcinoma cases was 5. R0 resection was achieved in all four malignant tumours. Other pathologies identified in resected specimens included a GIST ($n=1$: 9.5 cm tumour with moderate atypia and three mitosis per 50 hpf), duodenal adenoma ($n=5$) and lymphoma ($n=1$, Table 3).

Regarding the patient with lymphoma, this patient was investigated preoperatively with endoscopy and biopsy of a symptomatic duodenal lesion (biopsy pathology suggested an adenoma). Only the postoperative immunohistochemical stains on the resected specimen revealed the presence of a grade 2 follicular B cell lymphoma. This patient was subsequently seen by the haematology team in our institution. The median hospital stay was 14 days (range 6–42), including readmissions. There was no postoperative mortality.

The overall 30-day postoperative morbidity rate was 82 % ($n=9$), although complications were minor (Clavien 2 or less) in the majority ($n=7$, 78 %). Two patients (18 %) had major complications (Clavien 3 or greater), namely an anastomotic leak and a bleed from an anastomotic edge respectively. The anastomotic leak was managed non-operatively with broad-spectrum antibiotics and insertion of an abdominal drain under ultrasound guidance. The anastomotic bleed was treated by endoscopic placement of haemostatic clips. There were no

Fig. 1 Two different techniques used for D3 and D4 resection. **a** Black dashed line indicates the proximal duodenal transection line. **b** Duodenal remnant (D1 and D2) with preservation of the ampulla. **c** End-to-side duodeno-jejunal anastomotic reconstruction (black arrow). First jejunal loop brought to the supracolic compartment trough transverse mesocolon (straight grey arrow). **d** End-to-end duodeno-jejunal anastomotic reconstruction (black arrow). First jejunal loop brought to the supracolic compartment trough the space of D3–D4 under the Treitz ligament (curve grey arrow)



significant differences in morbidity rates or in postoperative length of stay between those who had end-to-end or end-to-side anastomoses. It appeared that the grade/severity of morbidity was less among those who had an end-to-end rather than end-to-side anastomosis (Fig. 2) and among those who had an adenoma or GIST resected compared to a duodenal adenocarcinoma (Fig. 3), although this did not reach statistical significance in either analyses.

Of the four patients with duodenal adenocarcinoma, only two had nodal involvement (T4N2 and T3N1) and

subsequently received systemic chemotherapy. Median survival time and disease-free survival of these four patients are respectively 13 (range 7–21) and 13 (range 4–18) months. Three patients are currently alive and two are disease-free at the moment. Early (4 months) disease recurrence was observed in the elderly lady operated for gastric outlet obstruction, who eventually died 7 months after the surgery. The patient who underwent GIST resection did not receive any adjuvant treatment due to concomitant metastatic prostate cancer from which the patient died subsequently 26 months

Table 2 Operative details

	N=11 (%)
Operative time (minutes) ^a	191 (120–240)
Blood loss (ml) ^a	675 (50–1500)
Number of duodenal segments resected	
One	4 (36)
Two or more	7 (64)
Reconstruction performed	
Primary	9 (82)
Roux-en-Y	2 (18)
Anastomosis performed	
End-to-end	5 (45.5)
End-to-side	5 (45.5)
Side-to-side	1 (9)

^aData expressed as median and range

Table 3 Postoperative outcomes

	N=11 (%)
Histopathology of duodenal lesions	
Adenocarcinoma	4 (36)
Adenoma	5 (46)
GIST	1 (9)
Lymphoma	1 (9)
Postoperative complications	
No complications	2 (18)
Clavien 1-2	7 (64)
Clavien 3-4-5	2 (18)
Length of stay (LOS), days (range) ^a	14 (6–42)
LOS: end-end anastomosis	8 (7–42)
LOS: end-side anastomosis	14 (6–34)

^aData expressed as median and range

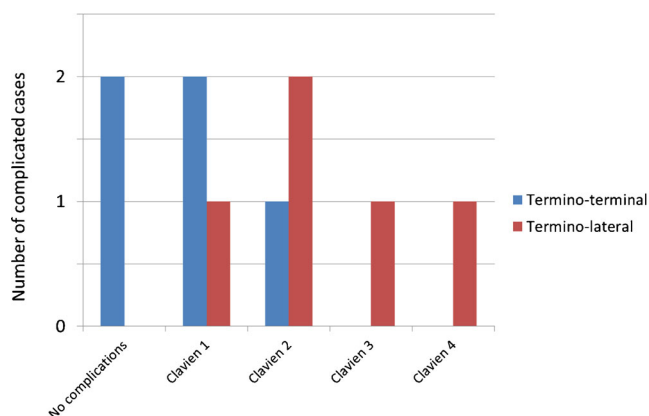


Fig. 2 Postoperative complication comparison between different anastomoses types

after the duodenal resection and with no evidences of duodenal disease recurrence.

Discussion

Limited pancreatic-sparing duodenal resection (DR) is infrequently performed in current practice due to the rarity of pathologies for which this procedure is feasible. More recently, however, DR has gained popularity as data emerges to support its safety and efficacy in adequately resecting duodenal lesions, both benign and malignant.^{5, 7-10, 14-20} DR has been reported to effectively treat lesions such as duodenal adenomas, GIST and adenocarcinomas arising from the first, third and fourth parts of the duodenum, with acceptable postoperative mortality and morbidity.

To our knowledge, our institutional experience with DR is one of the largest reported series of elective, limited DR for duodenal tumours. Our results confirm the feasibility and safety of this procedure, when performed by specialist hepatobiliary surgeons in a tertiary referral centre.

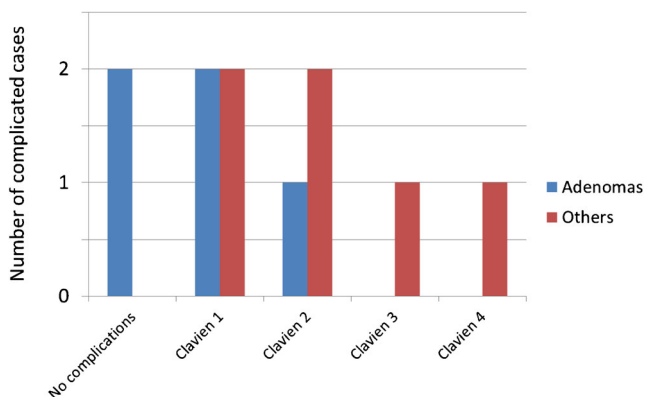


Fig. 3 Postoperative complication comparison between different tumour types

Although 9 of 11 patients in this series experienced a postoperative morbidity, the vast majority of these (78 %) were minor (respiratory tract or superficial surgical site infections) and did not require interventions or procedures, except for the administration of antibiotics. Only two major postoperative complications occurred in this series, both of which were related to the duodenal anastomosis performed (one leak, one bleed). Neither patient required reoperation, and both patients recovered without long-term sequelae. Regarding the preferred anastomotic technique, our experience suggests that both end-to-end and end-to-side primary anastomoses can be used to safely restore intestinal continuity after segmental resection, without differences in postoperative morbidity or length of hospital stay. The number of patients in this study did not permit a comparison between these two anastomotic techniques, although there appeared to be more severe (Clavien 3 and 4) complications with end-to-side anastomoses. Indeed, the aforementioned complications that were directly related to the anastomosis occurred in patients who had end-to-side reconstructions. Length of stay was also longer among those patients who had end-to-side anastomoses, although the numbers in each group were too small to permit multivariate analysis.

Segmental DR of localized duodenal malignancies can achieve excellent oncological outcomes, comparable to those described after pancreaticoduodenectomy.^{5, 14-20} R0 resection was achieved for all tumours in this series, including the invasive duodenal adenocarcinomas. Our data supports previous reports describing the oncological feasibility of segmental DR.^{5, 14-20} In our experience, the potential to achieve R0 resection in all cases, with a low rate of major postoperative complications, is consequent to careful patient selection preoperatively. All cases were discussed at a multidisciplinary team meeting after thorough workup. All our patients underwent diagnostic endoscopy, and more than 50 % had an abdominal CT to further evaluate the duodenal pathology. The relation of the duodenal lesion with the duodenal ampulla was carefully evaluated during the preoperative endoscopic study.

Although EUS was not used routinely as a preoperative test, it was undertaken for the assessment of larger duodenal lesions (more than 5 cm in diameter) and in patient where intrapancreatic CBD and pancreatic parenchyma involvement could not be ruled out on CT. The increased availability of EUS, along with its high negative predictive value for CBD involvement and its low morbidity, has already led to more widespread use of this imaging modality for duodenal pathologies in our centre. Preoperative investigations such as endoscopy and CT scan are essential for assessing resectability of the tumour and its anatomic relationship to the ampulla, the two major factors which determine whether the appropriate surgical approach is a limited DR or PD.

ERCP and MRCP were not routinely performed in the preoperative assessment of our patients. There is no evidence to support their use in staging duodenal tumours. We believe that ERCP in particular could increase morbidity without adding to the information obtained at endoscopy and EUS. MRCP may be useful in cases where CT and endoscopy fail to define the relationship of the lesion with the intrapancreatic CBD.

For D2 resections, our experience suggests that the best way to assess the relationship of the ampulla to the planned plane of resection is by palpation and direct visualization of the ampulla after creating the duodenotomy, rather than by intraoperative endoscopy or biliary cannulation. For these reasons, we believe that segmental resection of the duodenum should only be performed by expert pancreaticobiliary surgeons working in a high volume unit.

Our data suggests that D3 and D4 tumours (benign and malignant) are amenable for segmental resection if no involvement of the pancreas is demonstrated preoperatively. D1 and D2 resections were selected as the procedures of choice for benign tumours in those duodenal segments. The only preoperative biopsy-proven adenocarcinoma which underwent segmental resection in our series was causing gastric outlet obstruction and anaemia in an 81-year-old lady whose clinical status would not have permitted PD.

Therefore, our experience is comparable to that reported in current literature, which suggests the oncological feasibility of segmental resection for adenocarcinomas occurring in D3 and D4, but largely discourages segmental resection for known malignant lesions in D1 and D2.^{5, 14–20} Benign D1 and D2 lesions can be safely resected if pancreatic and ampullary involvement is excluded preoperatively or intraoperatively. Complete oncological (R0) resections were achieved for all malignant lesions in this series, with a median survival of 13 months.

Another potential advantage to preoperatively identifying tumours amenable to DR, which was not explored in this study, is the possibility to perform this procedure laparoscopically. A minimally invasive surgical approach would be imminently more feasible for a segmental DR, which requires just a single intestinal anastomosis, than a PD that typically requires three anastomoses to reconstruct the pancreatic duct, biliary tree and intestinal tract.

The limitations of this study include its retrospective design and limited number of patients involved, which did not permit subgroup analysis. However, our data suggests that the feasibility and safety of performing limited DR for selected duodenal tumours and indicates a need for prospective and possibly even randomized studies to further evaluate its role as an oncological procedure. Unfortunately, even in high volume and subspecialized oncology centres, the scarcity of resectable primary duodenal tumours limits the performance of randomized clinical trials to compare the outcomes of limited duodenal resection with PD. Given this currently insurmountable limitation, retrospective

studies such as this are the highest level of evidence on which the indication and rationale for DR should be based.

Conclusion

Segmental DR is a safe surgical technique that can be used for the treatment of benign and malignant duodenal neoplasms in carefully selected patients. Long-term postoperative follow-up and comparative studies are needed to confirm the efficacy of this infrequently performed procedure.

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References

- Kujath, P., O. Schwandner, and H.P. Bruch, *Morbidity and mortality of perforated peptic gastroduodenal ulcer following emergency surgery*. Langenbecks Arch Surg, 2002. **387**(7-8): p. 298-302.
- Sachdeva, A.K., H.A. Zaren, and B. Sigel, *Surgical treatment of peptic ulcer disease*. Med Clin North Am, 1991. **75**(4): p. 999-1012.
- Degiannis, E. and K. Boffard, *Duodenal injuries*. Br J Surg, 2000. **87**(11): p. 1473-9.
- Zhou, B., et al., *Pancreaticoduodenectomy versus local resection in the treatment of gastrointestinal stromal tumors of the duodenum*. World J Surg Oncol, 2013. **11**: p. 196.
- Sista, F., et al., *Adenocarcinoma of the third duodenal portion: Case report and review of literature*. World J Gastrointest Surg, 2012. **4**(1): p. 23-6.
- Adler, D.G., et al., *The role of endoscopy in ampullary and duodenal adenomas*. Gastrointest Endosc, 2006. **64**(6): p. 849-54.
- Hoepfner, J., et al., *Limited resection for duodenal gastrointestinal stromal tumors: Surgical management and clinical outcome*. World J Gastrointest Surg, 2013. **5**(2): p. 16-21.
- Johnston, F.M., et al., *Presentation and management of gastrointestinal stromal tumors of the duodenum: a multi-institutional analysis*. Ann Surg Oncol, 2012. **19**(11): p. 3351-60.
- Bourgouin, S., et al., *Duodenal gastrointestinal stromal tumors (GISTs): arguments for conservative surgery*. J Gastrointest Surg, 2013. **17**(3): p. 482-7.
- El-Gendi, A., S. El-Gendi, and M. El-Gendi, *Feasibility and oncological outcomes of limited duodenal resection in patients with primary nonmetastatic duodenal GIST*. J Gastrointest Surg, 2012. **16**(12): p. 2197-202.
- Kamath, A.S., et al., *Gastrointestinal stromal tumour of the duodenum: single institution experience*. HPB (Oxford), 2012. **14**(11): p. 772-6.
- Liang, X., et al., *Gastrointestinal stromal tumors of the duodenum: surgical management and survival results*. World J Gastroenterol, 2013. **19**(36): p. 6000-10.
- Yamashita, S., et al., *Pancreas-sparing duodenectomy for gastrointestinal stromal tumor*. Am J Surg, 2014. **207**(4): p. 578-83.
- Agrawal, S., et al., *Surgical management and outcome in primary adenocarcinoma of the small bowel*. Ann Surg Oncol, 2007. **14**(8): p. 2263-9.
- Bakaen, F.G., et al., *What prognostic factors are important in duodenal adenocarcinoma?* Arch Surg, 2000. **135**(6): p. 635-41; discussion 641-2.
- Kaklamanos, I.G., et al., *Extent of resection in the management of duodenal adenocarcinoma*. Am J Surg, 2000. **179**(1): p. 37-41.

17. Han, S.L., et al., *The surgical treatment and outcome for primary duodenal adenocarcinoma*. J Gastrointest Cancer, 2010. **41**(4): p. 243-7.
18. Tocchi, A., et al., *Adenocarcinoma of the third and fourth portions of the duodenum: results of surgical treatment*. Arch Surg, 2003. **138**(1): p. 80-5.
19. Bucher, P., P. Gervaz, and P. Morel, *Long-term results of radical resection for locally advanced duodenal adenocarcinoma*. Hepatogastroenterology, 2005. **52**(66): p. 1727-9.
20. Barnes, G., Jr., et al., *Primary adenocarcinoma of the duodenum: management and survival in 67 patients*. Ann Surg Oncol, 1994. **1**(1): p. 73-8.
21. Dindo, D., N. Demartines, and P.A. Clavien, *Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey*. Ann Surg, 2004. **240**(2): p. 205-13.